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Stormwater management in transition: The influence of technical and governance attributes in the case of Brussels, Belgium

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ABSTRACT

Worldwide, conventional stormwater management policies and practices are under pressure due to the malfunctioning of existing urban drainage systems, population growth, urbanisation and climate change. In response to these developments, we have seen an increase in the development and uptake of alternative actions. These actions often involve physical infrastructure moving from the underground to the surface and an increase of stakeholder interactions and involvement. We draw upon the literature on transitions of socio-technical systems to understand these changes in stormwater management policies and practices in the case of a local municipality in Brussels, Belgium. Building upon previous research by Rijke et al. (2013), we assert that every transition stage (early, middle, late) can be linked to typical activities. We particularly aim to understand how a transition process is influenced by technical attributes of actions, i.e. whether they are soft, green or grey, and by governance configurations, i.e. whether actions are more centralised or decentralised and more formal or informal. In doing so, we looked into the development, implementation as well as the diffusion of alternative actions. Our results show that in the early stage of transition, soft actions, such as manuals, legislation and economic incentives, prevail. In the diffusion of actions, decentralised processes and collaboration between formal institutions and informal networks play a key role. We further found that attention should be given to preventing the alienation of civil society during diffusion processes.

1. Introduction

In industrialised countries, drainage systems that were constructed in the 19th century are often no longer sustainable because of negative environmental impacts, such as urban flooding, waterway pollution and a decrease of biodiversity (Karvonen, 2011; Niemczynowicz, 1999). What characterises these systems is that they are governed by central decision-making authorities and use underground infrastructure to convey stormwater, as soon as possible, outside of urban areas (Chatzis, 1999). The environmental impacts and risks of these systems are growing due to increasing urbanisation and changing precipitation patterns (Gleick, 2000; Mitchell, 2006). As infiltration capacity is decreasing and extreme rainfall events are becoming increasingly common, the flow of polluted run-off, now increasingly often, overwhelms the drainage system (Niemczynowicz, 1999). In response to these challenges, so-called 'alternative' actions have been introduced. In the European context, the term 'alternative' action is used to contrast these approaches with conventional actions (Fletcher et al., 2014). In Australia, the term 'water sensitive urban design' is used to refer to similar approaches. What makes these approaches 'alternative' is that they are implemented with attention for the institutional and physical context of urban areas and ecological conditions (Schoeman et al., 2014; Tjallingii, 1996; Wong and Brown, 2009; Yu et al., 2012). In contrast to conventional approaches, they aim to manage stormwater at the surface, to reduce run-off and to avoid the pollution of waterways (Chocat, 2008; EEA, 2013; Hellier, 2015). Moreover, they are more decentralised and often driven by citizens and non-profit organisations (see Moretto and Ranzato, 2017). While conventional approaches heavily rely on 'grey' technical or engineering solutions, alternative actions are often characterised by 'soft' managerial, legal and policy approaches or 'green' ecosystem-based approaches (EEA, 2013). In practice, alternative actions are often an addition, rather than a substitute, to conventional actions (Chocat, 2008). This has to do with, on the one hand, the high quantity of stormwater to be managed and, on the other hand, the limited availability of land and the density of the existing urban fabric (Hoyer et al., 2012).

The application of alternative actions involves technical (e.g. infrastructure) and social changes (e.g. changing practices, regulations,

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policies, and networks). Urban drainage infrastructure is physically lifted from the underground to the surface, a place where civil society and non-profit organisations interact with administrative bodies and experts (Gandy, 2004). Since the integration of alternative actions into stormwater policies and practices involves structural changes in multiple elements, we understand this process as a transition of a socio-technical system, which encompasses technologies, institutions, rules, practices and networks (Smith et al., 2005). A transition involves structural changes in multiple elements of a socio-technical system (Brugge et al., 2006; Pahl-Wostl, 2008; Rotmans et al., 2001; Smith et al., 2010) and can be understood as a process consisting of multiple stages: early (pre-development, take-off), mid (acceleration) and late (stabilisation) (Rotmans et al., 2001; Rijke et al., 2013). Rijke et al. (2013) show that these early, mid and late stages can be associated with typical activities. For example, network formation is a typical activity in the early stage of a transition whereas regulation is typical in the late stage. A typical activity can include multiple actions, which have the same main objective (Rijke et al., 2013). For instance, the typical activity 'network formation' can include an action aiming to establish a working group composed of local and regional actors and another action aiming to organise a roundtable of discussion between different actors. Actions may contribute to a transition when they are diffused (Boulanger, 2008; Brown et al., 2013). Diffusion is understood here as the duplication and expansion of knowledge (artefacts, hard or soft knowledge) in new locations and/or institutionalisation (Vreugdenhil, 2010) and the capacity of actions to influence other actions (Boulanger, 2008).

Building upon transition and urban water management studies, we assert that the implementation and diffusion of stormwater actions are not only influenced by technical attributes, but also by the governance attributes that are associated with them (i.e. who manages water and how) (Brown and Farrelly, 2009; Niemczynowicz, 1999; Van de Meene et al., 2011). To understand the governance attributes of an action, we use the concept of 'governance configuration'. Stormwater governance is multi-levelled (i.e. a process carried out at different levels of the society) and polycentric (i.e. several actors have the capacity to influence the governance process) (Knieper and Pahl-Wostl, 2016; Pahl-Wostl, 2015). We consider the fit-for-purpose framework – an operational tool of multi-level and polycentric stormwater governance – to characterise governance configurations according to two dimensions: verticality (centralised and decentralised processes) and horizontality (formal institutions and informal networks) (Rijke et al., 2012). Verticality refers to the centrality of the initiating actor in the decision-making process (Rousseau, 2011). Horizontality characterises the relation between actors, including whether the action is initiated by formal institutions, which are under formal regulation, or informal networks (Pahl-Wostl, 2015). Even though researchers agree that governance configurations influence the diffusion of actions, yet few studies link governance configurations to technical attributes of actions and transition stages (Pahl-Wostl et al., 2011; Rijke et al., 2013; Van de Meene et al., 2011). Our study addresses this knowledge gap by providing an improved understanding of how the technical and governance attributes of alternative actions influence a transition process, including the moving from one transition stage to another through the diffusion of actions. We acknowledge that other attributes of actions may be relevant for a transition process, such as the visibility of an action. However, we focus on these two attributes as these also characterise the main differences between conventional and alternative actions.

We investigate the case of the municipality of Forest (French name) or Vorst (Flemish name) in Belgium where local administration, non-profit organisations, and community-based organisations have initiated and implemented alternative actions in stormwater management. Some of these actions are currently being diffused to other municipalities. Central in the case study are the following questions: What are the technical and governance attributes of actions that were recently developed or implemented to improve urban stormwater management? How do these actions correspond to the typical activities of a transition process? Which of the alternative actions are diffused and therefore contribute to wider change processes? The remainder of this paper is structured as follows. Section 2 presents the study's conceptual framework. Section 3 provides the research methodology. Section 4 presents the case study results. These results and their implications are discussed in Section 5. The final section presents our main conclusions.

2. Transition in urban stormwater management

Sustainability transitions are long-term processes in which socio-technical systems move towards a sustainable production and consumption of resources (Markard et al., 2012). We consider alternative actions here to be examples of socio-technical experiments that drive transition processes (Luederitz et al., 2016) and have technical and governance attributes (Sengers et al., 2016).

2.1. Technical and governance attributes of stormwater actions

To differentiate actions in terms of their technical attributes, we distinguish between soft, green and grey actions (EEA, 2013). In the stormwater management domain, green actions are on-ground, small-scale devices for harvesting, treating, infiltrating and reusing stormwater (e.g. swales, wetlands, rainwater gardens or rainwater tanks) in order to complement underground drainage pipes (Howe et al., 2011). Soft actions include guidelines, legislation, and manuals sustaining the application and integration of these devices in the current institutional and physical context (Hoyer et al., 2011) and often involve changes in water governance (EEA, 2013). In the literature, they have received less attention than green actions since their impact is difficult to assess (Taylor and Wong, 2002). Nevertheless, soft and green actions often support each other's implementation (Brown and Clarke, 2007).

Barriers to the implementation of alternative actions are not only of a technical nature, but are also rooted in prevailing governance structures, which are influenced by societal values, risk perceptions, individual factors and loss of culture (Adger et al., 2009; Brown et al., 2009; Niemczynowicz, 1999; Sharma et al., 2016; Van de Meene et al., 2011). Stormwater governance is polycentric and multi-levelled with actors and networks formulating and establishing policy at different levels of the society (Knieper and Pahl-Wostl, 2016; Pahl-Wostl, 2015). As a result, decision-making stances overlap and are interconnected both vertically and horizontally around the issue to be governed (Bulkeley and Betsill, 2005; Hooghe and Marks, 2003). In polycentric systems, new governance configurations may appear at the local level as a result of the relations that form between state and non-state actors (Bulkeley and Betsill, 2005). We use the term 'governance configuration' as the combination of two dimensions of multi-level governance: verticality and horizontality.

The first dimension of a governance configuration, verticality, refers to the centrality of the initiating actors from an administrative and political perspective. The initiating actor of an action can belong either to the centralised decision-making system or to the decentralised decision structures. Centralisation relates to the unity and hierarchy imposed by the State in the process of decision-making (Rousseau, 2011). Decentralisation of administrative and political power occurs when the State gives local collectives (such as local councils) the ability to organise and manage certain local affairs (Bardhan, 2002; Pahl-Wostl et al., 2006; Tellier, 1969). Decentralised processes are recognised in the literature on sustainability transitions as key in empowering local councils to influence the contribution of actions to transition (Kemp et al., 1998).

The second dimension, horizontality, refers to whether the action was initiated by formal institutions or informal networks. In this paper, we start from the premise that all individual actors, either state or non-state actors, are part of an established group of influence. Formal institutions, in a broad sense, refer to the official regulations and

mechanisms that guide the interactions among actors, such as legal frameworks, macroeconomic policies or political regimes (Leach et al., 1999; Pahl-Wostl, 2015). Informal networks function outside of official regulations without a written consent and are based on social norms (Guha-Khasnobis et al., 2006). The difference between formal institutions and informal networks does not necessarily lead to incompatibility. Indeed, their complementarity has been proven to increase the capacity of governance configurations to enable a change in water management (Lange et al., 2013; Rijke et al., 2013; Voß, 2007). In transition management, informal networks fill in the gaps left by formal institutions in the current practices (Bos and Brown, 2012). Nevertheless, formal institutions can assist informal networks to have an impact on the process of policy making (Loorbach, 2010).

2.2. Stages of transition and diffusion

During the transition process, changes in socio-technical systems occur through different stages (Geels and Schot, 2007; Rijke et al., 2013; Rotmans et al., 2001). An empirical study on the transition of urban stormwater management in Australian cities identified and characterised three stages of transition by a series of typical activities and effective governance configurations that support a transition. For example, in the early stage, the typical activities encountered in stormwater management at the city level are network formation, learning, experimentation, response to a crisis and establishment of policy decisions. In this stage, decentralised processes and informal networks prevail but collaboration with formal institutions is essential to further diffuse actions (Rijke et al., 2013).

A movement from early to mid stages occurs with an increasing implementation of innovation (Rijke et al., 2013). This increase involves the wide diffusion of the innovation (Geels, 2005). We distinguish between different types of diffusion, including replicating (i.e. the duplication of similar scale, but different location and time), and scaling up (i.e. the expansion in scale and time or/and institutionalisation) (Vreugdenhil, 2010). Empirical studies have shown that sustainability innovations, such as alternative actions, have the potential to contribute to a transition by generating social learning and empowerment through the process of scaling up (Brown et al., 2013). Scaling up usually leads to a change in governance configurations (Bos and Brown, 2012). Van den Bosch (2010) makes a distinction between spatial scaling up (i.e. widening the scope of an action) and scaling-up (i.e. institutionalisation of an action).

A transition process enters a late stage when the integration of innovation reaches the status quo of the system (Rijke et al., 2013). Table 1 provides a more detailed view on the relations between transition stages, typical activities and governance configurations in each of the early, mid and late stage of transition.

2.3. Conceptual framework

Building upon the study by Rijke et al. (2013), this paper aims to provide new insights into how technical and governance attributes of actions promote diffusion and, thus, a move from one transition stage to another. Fig. 1 summarises our conceptual framework, including guiding questions. We first characterise actions in terms of their technical and governance attributes. The technical attributes are linked to whether actions are soft, green or grey (EEA, 2013). Based on the fit-for-purpose governance framework – an operational tool to evaluate the fit of governance configurations in a specific setting (Rijke et al., 2012) – we analyse governance attributes in terms of: verticality (centralised or decentralised process) and horizontality (formal institutions or informal networks). Second, we relate the observed actions to the activities that are according to Rijke et al. (2013) typically encountered in the different transition stages (early, mid, late) (see Table 1). Third, we examine which alternative actions contribute to a transition. We analyse if an action was replicated, spatial scaled-up or scaled-up (institutional perspective) (Boulanger, 2008; Van den Bosch, 2010; Vreugdenhil, 2010). These guiding questions are addressed in the case study.

3. Research approach

3.1. A case study of a transition in stormwater management

The uptake of alternative actions in stormwater management, acting as a socio-technical system, is a highly complex process. Understanding this process requires an in-depth case study research to investigate how the context questions and supports previous empirical findings (Groat and Wang, 2013; Yin, 2014). A local municipality from Brussels Capital Region was selected as a case study for an in-depth analysis.

In line with the European Water Directive (European Commission, 2000), the regional water management plans of Brussels Capital Region promote the implementation of alternative actions in stormwater management (e.g. small-scale devices for stormwater infiltration and harvesting) next to conventional ones (e.g. maintenance of the current infrastructure) to avoid overflows of the sewer system (Bruxelles Environnment, 2016). Moreover, in urban planning policies, the regional administration released mandatory regulations for new constructions to integrate alternative actions, such as green roofs, rainwater tanks, or permeable surfaces (Bruxelles Environnment, 2015). However, in practice, conventional actions prevail. In Brussels Capital Region, Forest – Vorst (F – V) municipality is recognised as frontrunner when it comes to the uptake of alternative actions in stormwater management (Jacobs, 2013; Kohlbrenner, 2015). For example, in the region, the municipality was the first one to create a municipal water department to manage alternative and conventional actions (Mannes and Da Cruz, 2015).

The particularity of the case study lies in the large number and

Table 1
Transition stages. Table illustrating the hypothesis developed by Rijke et al. (2013) according to typical activities and governance configurations occurring in Australian urban stormwater management. The table is based on (Rijke et al., 2013, p. 64,70) and adapted by the authors.

Transition stages (Rijke et al., 2013)	Socio-technical transition stage (Brugge et al., 2006; Rotmans et al., 2001)	Typical activities (Rijke et al., 2013)	Effective governance configurations (Rijke et al., 2013)
Early stage	Pre-development	Network formation, experimentation, learning	Decentralised processes and informal networks
	Take-off	Response to a crisis or establishment of a policy decision	Decentralised processes with formal institutions and informal networks
Mid stage	Acceleration	Increasing implementation of innovation	Centralised processes in parallel with decentralised processes and informal networks
Late stage	Stabilisation	Regulation and legislation to establish the status quo	Centralised processes and formal networks
	–	Losing faith, searching for new/alternative solutions	Decentralised processes and informal networks

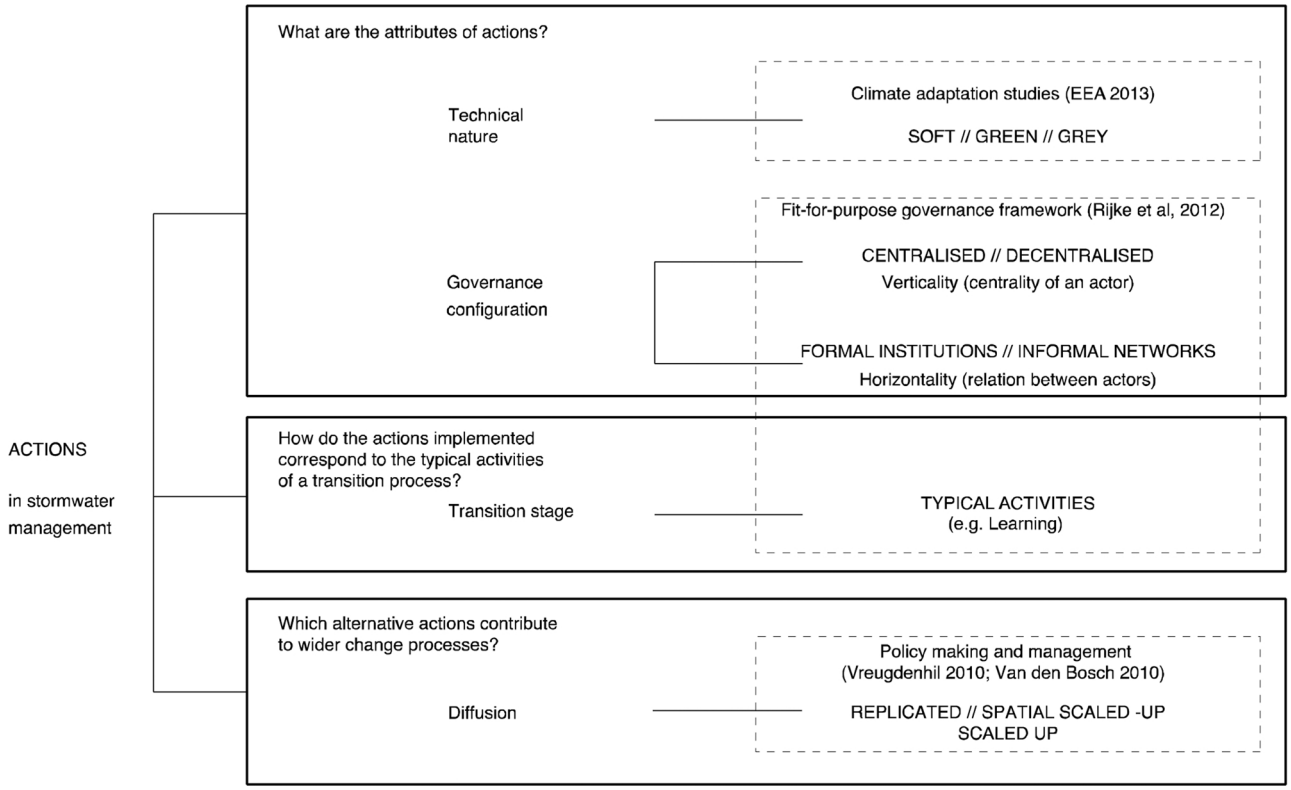

Fig. 1. Conceptual framework.

variety of actions carried out by regional and local actors to address the risk of urban flooding. This makes F – V municipality a highly informative case that can help to understand why alternative actions in stormwater management are diffused and how technical and governance attributes might influence these processes. The case has the potential to reveal implications for similar municipalities, which may become key actors in the transitioning of cities towards more sustainable water management.

3.2. Methods

This in-depth case study benefited from several ongoing research projects carried out by the first author in Brussels Capital Region. Data were collected through the analysis of policy reports, legislation and regulation documents, and media reports on stormwater management actions. Primary data were further collected through five individual semi-structured interviews and three group interviews with actors actively involved in the water sector in F – V municipality. These actors included representatives of local administration, representatives of non-profit organisations and public water agencies. All respondents had an active role in initiating or implementing one or several actions in the municipality. The semi-structured interviews provided information about why alternative actions were initiated by the respondents. The group interviews provided an overview of the actions carried out by actors who belonged to an established group. In addition, we carried out six short interviews with stakeholders who were actively involved in actions that were implemented in the municipality and Brussels Capital Region. These stakeholders were selected because of their active involvement and represented environmental agencies, local associations and researchers. Primary and secondary data regarding the evolution of ongoing actions in stormwater management were collected through public conferences and local assemblies in the period between April 2014 and September 2015. We attended six public conferences organised by local non-profit organisations, two urban design workshops at the Faculty of Architecture of the Université libre de Bruxelles and three meetings among practitioners, researchers and administration on water issues in Brussels. During these events, we used participant observation to collect information about the ongoing actions and the actors involved.

Our case study focuses on actions that were initiated between 2009 and 2015. In this period, 21 actions were either already implemented, being implemented or planned to improve flood protection. The case study includes the low-lying areas of the municipality, where most flooding events occur, as well as parts of the upper areas, with a low risk of flooding, where similar actions were carried out. Relevant information about each action was organised in routine word-processing tools (Word and Excel). The data were analysed using a qualitative inductive approach. We elaborated research questions based on theoretical propositions from the literature on sustainability transitions, (urban) water management and governance. We created tables to allow for cross-case synthesis. These tables displayed information about each action according to the attributes that were identified in the literature (Yin, 2014).

4. Case study and results

4.1. Actions in Forest-Vorst municipality driven by local and regional actors

Driven by flood protection and sustainability requirements, which came both from regional and local actors, several changes took place in stormwater management in F – V municipality over the last decades. A chronological overview of all actions between 2009 and 2015 and the initiating actors is provided in Table 2. The regional government and regional water agencies are responsible for the management and maintenance of the combined sewer systems, which ensure the drainage function in the municipality. Their conventional actions aim to upgrade the existing combined sewer system with underground retention basins to serve as a buffer during high precipitations (action 5). As a response to the regional pressure, the Local Council has been the first in Brussels to establish, in 2010, a local working group (action 4) and, in 2012, a

Table 2
Overview of all actions carried out in F – V municipality in the period between 2009 and 2015. The overview includes all actions that aimed to improve protection against pluvial flooding from stormwater, wastewater and surface water, regardless of their application scale. The table also includes an action that was initiated in 1997 but relevant to the period under study because it involved the creation of the neighbourhood committee Stop Inondation.

# Action	Timeline (Chronological order according to the starting year)	Actions Short title	Actions Description	Actors initiating the action
1.	(1997 – present)	Raising awareness	Organising several activities to raise awareness in the Local Council on the flood-related problems	Neighbourhood Committees
2.	(2009; 2015)	Urban planning regulation	Integration of alternative actions into the local urban planning regulations (RCU)	Local council
3.	(2010 – present)	Practical guidelines	Elaboration and distribution of information on practical guidelines to the inhabitants to avoid and mitigate flooding	Forest-Vorst (F – V) Water Department
4.	(2010 – present)	Local working group	Creation of a coordination working group to exchange knowledge and expertise between experts from the local administration and representatives of public water agencies	(F – V) Water Department
5.	(2011 – 2013)	Retention basins	Construction of two underground retention basins	Regional water agencies, (F – V) Local council
6.	(2011)	On-ground works	Restoration of the ponds in Jacques Brel Park to integrate rainwater harvesting and drainage. Renovation of parking with permeable pavement for stormwater infiltration	(F – V) Water Department
7.	(2014, 2015)	Round tables	Organisation of round tables to engage in discussion among state and non-state actors on water-related issues	EGEB NGO (F – V) Local Council, Neighbourhood Committees
8.	(2011 – present)	Bassin Versant Solidare	Development of the concept of Bassin Versant Solidare (catchment solidarity) to enhance collaboration among stakeholders located in the same urban watershed	EGEB NGO, Neighbourhood Committees
9.	(2011 – present – project level)	New Urban Rivers	Development of New Urban Rivers project to recreate urban streams through the use of small-scale devices for harvesting, infiltrating and draining stormwater on the surface. E.g. Les sources du Calvaire et du Leybeek	EGEB NGO, Neighbourhood Committees
10.	(2012)	Flood protection plan	Release of local flood protection management plan	(F – V) Local Council
11.	(2012 – present)	Research projects	Elaboration of several research projects investigating the causes of flooding, the potential of small-scale devices and the interaction among actors (Jacobs, 2013; Kohlbrenner, 2015; Ranzato, 2016)	VUB and ULB universities
12.	(2012 – present)	Water department	Creation of a municipal water department to tackle local water-related issues	(F – V) Local Council
13	(2012 – present)	Urban stream archive	Investigation of municipal urban planning archives to collect relevant information on the existence of ancient urban streams and effects of urbanisation	Neighbourhood Committees
14.	(2013 – present)	Map-it	Organising of Map-it sessions and guided tours to collect information and design scenarios on water-related issues	EGEB NGO, Neighbourhood Committees, Architecture offices, academia
15.	(2013 – 2015 – project level)	Blue and Green axis	Development of the Blue and Green axis project to integrate vegetated swales and rainwater gardens at the street level	EGEB NGO, Neighbourhood committee
16.	(2013)	Water Day	Organising activities celebrating Water Day in the municipality	Local Council, (F – V) Water Department
17.	(2014 – present)	Economic incentives	Release of regional and local economic incentives for new constructions to integrate small-scale devices for stormwater harvesting and infiltration	Local Council, (F – V) Water Department
18.	(2014 – 2015)	Stream dredging	Dredging of urban streams to increase water flow initiated (Zenne and Geleytsbeek Rivers)	Brussels Environmental Agency
19.	(2014 – 2015)	Update sewer system	Renovation and update of the combined sewer system to increase drainage capacity	(F – V) Local Council, Regional water agencies
20.	(2015)	Recommendations drainage systems	Release of recommendations for surface drainage systems	Regional water agencies
21.	(2015)	Water path (Fr. Tracé de l'eau)	Further development of New Urban Rivers in a larger area of the municipality with regional funds	(F – V) Local Council

water department, to collaborate with the regional water agencies (action 12) (Mannes and Da Cruz, 2015). Since 1997, the neighbourhood committee Stop Inondations initiates actions in the municipality to raise awareness on water-related problems (action 1). In support of the neighbourhood committee, the non-profit organisation, Les États généraux de l'eau à Bruxelles (EGEB NGO), has been active in the municipality to engage citizens' participation in water-related issues (Kohlbrenner, 2015). Nevertheless, starting with 2011, during the construction of one of the retention basins (action 5), they disagreed with plans that were proposed by the regional government because of the high costs involved and the lack of benefits to the urban environment and proposed new actions. In collaboration with the local administration, they have seized the opportunity to propose the uptake of alternative actions, including both soft and green actions in stormwater management (e.g. action 7, 8 and 9) (Bastin et al., 2015; Kohlbrenner, 2015).

4.2. Technical and governance attributes of actions and typical activities in the transition process

We characterised each action that was carried out in the municipality in terms of technical and governance attributes, which we associated with typical activities encountered in the transition process. Fig. 2 provides an overview of this characterisation.

As Fig. 2 shows, the majority of the actions that were carried out in F – V municipality can be characterised as soft. For example, the neighbourhood committees exerted pressure during the Local Council's official meetings to raise awareness about the urgency of flood-related issues in the area (action 1). Other examples of soft actions led by the Local Council were to promote the uptake of alternative actions through legislative changes (actions 2 and 10) and economic incentives (action 17). Green actions are still in the planning phase with just few implemented. For example, the Local Council supported the construction of a project to revitalise an urban park and to transform non-permeable parking areas into permeable areas (action 6). Furthermore, grey actions are the main type of actions realised by the regional water agencies, which mainly focus on the renovation and improvement of the sewer system to drain stormwater (action 5). Nevertheless, the increase in the number of green actions in time reveals a tendency to continue the transition in stormwater management towards a mid-stage.

The large number of actions and actors engaged in the stormwater management in F – V municipality led to the development of a variety of governance configurations. Our analysis shows that informal networks are active in initiating alternative actions, soft or green, but formal institutions predominate in their implementation. Nevertheless, they have complementary purposes. Actions driven by informal networks are dedicated to raising awareness on water-related issues (e.g. action 1), to engage multiple stakeholders in the discussion (e.g. action 7), and to produce knowledge based on historical and social research (e.g. action 13). Formal institutions focus either on multiplying instances of decision-making in stormwater management by organising working groups and specific departments (e.g. action 12), or on changing relevant legislation in order to integrate alternative actions in urban planning regulations (e.g. action 2). With regard to the centrality of actors, we found that centralised processes involved the implementation of grey actions whereas decentralised processes favoured green actions. Grey actions for critical flood protection are driven by centralised processes, from the regional level down to the local level, for instance, actions mandated by regional water agencies (action 5). Decentralised processes drive green actions for improving the urban environment through a collaborative process, such as, restoring open-

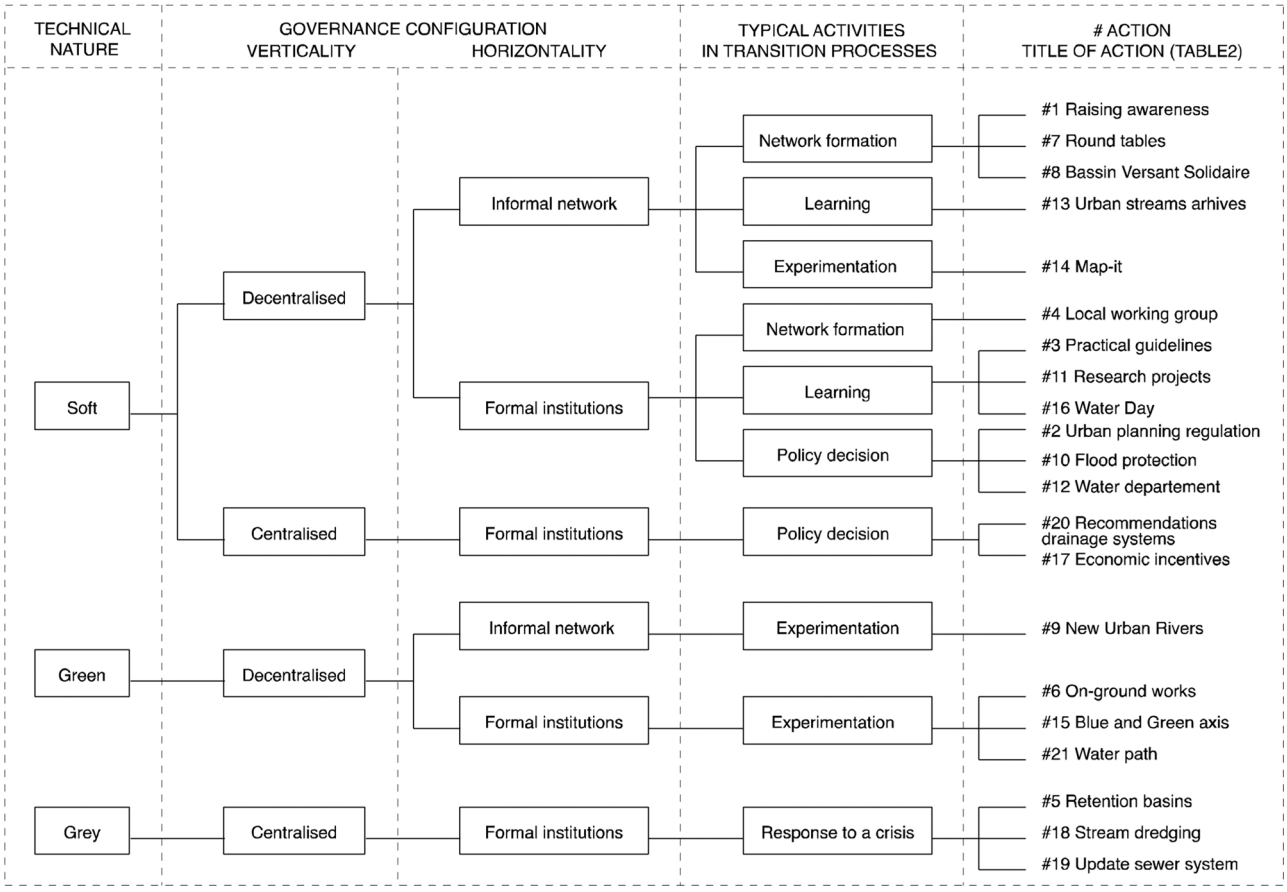

Fig. 2. Characterisation of actions in the case study according to technical attributes, governance configurations and typical transition activities.

air pounds in Park Jacques Brel (action 6). Another example is action 9, New Urban Rivers, that aims to create new humid areas through harvesting, treatment and drainage of stormwater on the surface following the path of ancient urban streams in Brussels' urban watersheds (Bortolotti et al., 2017; Kohlbrenner, 2015).

All actions carried out in the municipality can be associated with the activities that are typically encountered in the early stage of transition (see Table 1 and Fig. 2). Actions associated with network formation and learning are soft and followed a decentralised process of decision-making with both formal institutions and informal networks. For example, to form a network, the water department initiated a working group composed of representatives of local administration and regional public water agencies to exchange knowledge of water-related issues (action 12). Green actions focused on experimentation, but they remained in the planning phase. The New Urban Rivers project (action 9), for example, included proposals to implement small-scale devices for harvesting, treatment and drainage of stormwater, but none of these proposals is realised yet. Several actions were categorised as decentralised policy decisions. They were initiated by formal institutions in order to promote the implementation of alternative actions. For example, the flood management plan of F – V municipality was the first in Brussels to recognise the benefits of alternative actions to flood protection (action 10). All actions that were taken in response to a crisis, such as, a flooding event, were initiated by formal institutions through a centralised process. On these urgent occasions, grey actions, such as, the maintenance and renewal of the combined sewer system (action 19) and the implementation of underground retention basins (action 5) were promoted.

4.3. Diffusion of alternative actions

Alternative actions contribute to a transition by moving from one stage to another if they are diffused. An overview of all actions and their diffusion is provided in Table 3. According to the diffused actions in F – V municipality, three main findings emerge.

Most actions that were both replicated or scaled-up were soft actions and, thus, are likely to involve changes in the governance system. The diffused actions initiated in F – V municipality aim to consolidate the collaboration among local and regional state actors. For example, action 4 serves as inspiration for the regional administration to organise working groups for every urban watershed, composed of representatives of local administrations, regional water agencies and the Brussels Environmental Agency. Consequently, an action that was initiated through a decentralised process became a centralised policy at the regional level. However, this institutionalisation also led to a breakage of the relations between the administration and non-profit organisations.

All diffused actions were driven by decentralised processes that were initiated by formal institutions or informal networks. The case study results indicate that actions initiated by formal institutions are more likely to be scaled-up. For example, the organisation of Water Day (action 16) inspired the regional administration to organise yearly events in Brussels Capital Region. In addition, the creation of a water department at the local level (action 12) inspired the regional administration to appoint a local representative for water at each municipality in Brussels. Actions initiated through informal networks were either spatially scaled-up or replicated. For example, actions 8 and 14 were both replicated by the same initiating organisation at a larger geographical scale in Brussels: an urban watershed, and, respectively, in other municipalities in Brussels.

Several soft actions that took the form of experimentation were replicated. For example, the organisation that initiated Map-it sessions (action 14), which involves the collaborative mapping of water-related issues in a given area and was used as a first step to identify possible green actions, also implemented this action in other municipalities in Brussels. A particular case of diffusion is the New Urban Rivers project (action 9). This action was replicated twice, first, by the initiating non-profit organisation in other municipalities and, second, by the Local council for a larger area of F – V municipality. The latter involved a process of institutionalisation and led to action 21 (Water path).

5. Discussion

The case study has provided in-depth knowledge of the early stage of transition. At this stage, the contribution of the actions to the overall sustainability of the system is difficult to evaluate due to the lack of physical transformations. Our study has linked the technical and governance attributes of actions to diffusion in order to understand how it influences the move from one transition stage to the other. Three important insights emerge on how alternative actions contribute to transition.

The case of F – V municipality shows that the technical nature of

Table 3
Overview of actions and their diffusion. The number located near the title of the action represents the chronological positions in Table 2.

Governance configuration	# Action (See Table 2 for details)	Technical attribute	Observed Typical activities	Diffusion (Explanation on the new action resulted in the process of diffusion)
Centralised Formal Institutions	#5 (Retention basins) #19 (Update sewer system)	Grey	Response to a crisis	–
	#17 (Economic incentives) #20 (Recommendations drainage systems)	Soft	Policy decision	–
	#18 (Stream dredging)	Green	Response to a crisis	–
Centralised Informal Networks	–	–	–	–
Decentralised Formal Institutions	#2 (Urban planning regulation)	Soft	Policy decision	–
	#12 (Water department)	**Soft**	**Policy decision**	**Scaled-up**
	#10 (Flood protection plan)	Soft	Policy decision	–
	#3 (Practical guidelines) #11 (Research projects)	Soft	Learning	–
	#16 (Water Day)	**Soft**	**Learning**	**Scaled-up**
	#4 (Local working group)	**Soft**	**Network formation**	**Scaled-up**
	#6 (On-ground works) #15 (Blue and Green axis) #21 (Water path)	Green	Experimentation	–
Decentralised Informal networks	#1 (Raising awareness) #7 (Round tables)	Soft	Network formation	–
	#8 (Bassin Versant Solidare)	**Soft**	**Network formation**	**Spatial scaled-up**
	#13 (Urban stream archive)	Soft	Learning	–
	#14 (Map-it)	**Soft**	**Experimentation**	**Replicated**
	#9 (New Urban Rivers)	**Green**	**Experimentation**	**Replicated**

actions – soft, green or grey – can be related to different typical activities and degrees of diffusion. In the case study, soft actions were linked to the typical activities of learning, network formation and policy decision, green actions were associated with experimentation and grey actions with response to a crisis. We further observed that whereas soft actions were often replicated and scaled-up, only one green action was replicated. This may be related to the fact that green actions often have to be preceded by soft actions since the safe implementation of green actions requires changes in 'invisible elements' such as rules, which are the object of soft actions (Farrelly and Brown, 2011). In other words, soft actions could provide the basis for societal and institutional change needed to diffuse green actions (Bos and Brown, 2013).

Secondly, our case study illustrates the adaptability of decentralised processes to promote alternative actions. Yet, our case study also shows that centralised processes may lead civil society to lose trust in the actions driven by the regional administration, especially when they are institutionalised. For example, the scaling-up of a local working group towards the regional level (action 4) led to the alienation of non-profit organisations in the process. Nevertheless, our case study also supports previous studies revealing that decentralised processes mainly drive the uptake of alternative actions in the early stage of transition, while centralised processes have the potential to ensure continuity and diffusion of actions towards a mid-stage of transition (Pahl-Wostl, 2015; Rijke et al., 2013). This is due to the fact that centralised processes have the capacity to quickly react to a crisis and have an effective coordination of activities (Rijke et al., 2013) through the use of administrative arrangements and policy instruments (Van de Meene et al., 2011).

Thirdly, our case study highlights that the chance of diffusion depends on the initiating actor. Informal networks, such as the collaboration between neighbourhood committees and non-proofit organsiations in the case study, developed new ideas and projects, but were lacking the financial and institutional capacity to physically construct them (e.g. action 9). When the local municipality took over the coordination of this action, this ensured continuation but it also diminished the role of informal networks. The challenges to realise and diffuse actions, faced by informal networks in F – V municipality, align with findings of previous studies. In the early stage of transition, informal networks act in the shadow. However, to challenge current practices, they need to create a connection with formal institutions (Meijerink and Huitema, 2010). Formal institutions can provide financial support to enhance the chances of small-scale actions to be translated into urban water management (Farrelly and Brown, 2011). Moreover, the collaboration with formal institutions is essential to diffuse actions and increases the effectiveness of governance configurations in achieving the objective (Pahl-Wostl, 2015; Rijke et al., 2013). This does not mean that informal networks should be disregarded or reduced by the collaboration with formal institutions, but rather they should be strengthened to assist tackling societal problems, such as water-related issues (Bos and Brown, 2012).

6. Conclusions

Very few studies have focused on the links between governance configurations, technical attributes of actions and transition stages in stormwater management. The aim of our study was to address this knowledge gap and to bring insights on how the technical and governance attributes of alternative actions inform on the move from one transition stage to another through the diffusion of actions.

The actions carried out in F – V municipality were characterised by a wide diversity of governance configurations and technical attributes. The actions are all rather specific to the early stage of transition. The case study supports findings of previous studies which show that decentralised processes prevail in the early stages of transition and that collaboration between formal institutions and informal networks enables the further diffusion of actions (Rijke et al., 2013). The interest in creating these collaborations is that, while having the same objectives, actors can produce jointly better support for policy decision (Loorbach, 2010). Local municipalities assist informal networks to influence policy making through a multi-level, multi-phase and multi-actor approach (Loorbach, 2010) and are placed as key actors to strengthen the collaboration between formal and informal networks (Kemp et al., 1998). However, closer attention should be given to the upcoming loss of collaboration through diffusion.

The case study showed that soft actions are the main diffused type of activity in the early stage of transition. Soft actions have the capacity to support and promote green actions in the planning, design and implementation phases. Soft actions, if complemented by green and grey actions, are crucial to achieve a transition (Hegger et al., 2007). Further research could focus on relating these findings to concepts such as strategic or conceptual niche management, where actions are seen as opportunities to develop learning processes and new technologies (Kemp et al., 1998).

For municipalities that face similar challenges in stormwater management, the case has three implications. Firstly, policies should recognise the impact of soft actions on the transition in stormwater management, similar to green and grey actions. Under these conditions, early stage transition actions can receive recognition for their advancements, even if they do not immediately present visible transformation in the urban environment. In the early stage, soft actions are set and replicated, which is an important condition for transitioning to a new stage. Secondly, actions might have different results depending on who and how initiates them. While decentralised processes and informal networks create conditions for network formation, learning and experimentation, centralised processes and formal institutions can promote further diffusion, institutionalisation and a move towards a mid-stage of transition. However, centralised processes may also alienate non-state actors from actions since they involve moving away from local problems. Thirdly, the case supports that insights from transition studies are applicable not just at the city level but also at the local, municipal level (Rotmans et al., 2001). Further research is needed to understand how actions initiated through decentralised processes and informal networks can be scaled-up while maintaining the input received from non-state actors objectives.

Conflicts of interest

None.

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